

Sub A1

What is claimed is:

- 2 1. An arc fault detector for a power line system, comprising an upstream/downstream  
3 discriminator circuit, wherein said discriminator circuit detects when steps in a  
4 magnitude of a load current and steps in a magnitude of a line voltage are in phase for  
upstream transient events, and out of phase for downstream transient events.
- 1 2. An arc fault detector as in claim 1, wherein said transient events produce a high  
2 frequency spectrum.
- 1 3. An arc fault detector as in claim 1, wherein said transient events produce a low  
2 frequency spectrum.
- 1 4. An arc fault detector as in claim 1 wherein said steps in load current are detected  
2 with a current transformer.
- 1 5. An arc fault detector as in claim 1 wherein said steps in load current are detected  
2 across an impedance connected in series with said power line.
- 1 6. An arc fault detector as in claim 1, wherein said steps in line voltage are detected  
2 with a high pass filter connected across said power line.
- 1 7. An arc fault detector as in claim 1, wherein said steps in load current produced by  
2 steps in line voltage are connected to at least one input of a microprocessor.
- 1 8. An arc fault detector as in claim 1, wherein said out of phase steps in line voltage  
2 and load current are produced by a line voltage drop across an upstream line  
3 impedance.
- 1 9. An arc fault detector as in claim 8, wherein said line impedance is the inherent line  
2 impedance of said power line.

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1 10. An arc fault detector as in claim 8, wherein said line impedance is an impedance  
2 introduced within said power line.

Sub A2  
2 11. An arc fault protection device, protective of a branch circuit portion of a power  
line electrical distribution system and connected to a load, comprising:  
3 a first sensor for detecting fluctuations in load current;  
4 a second sensor for detecting fluctuations in line voltage; and  
5 a discriminator for comparing the polarities of said fluctuations;  
6 wherein said comparison indicates whether an arc fault or arc mimicking noise  
7 is located in said branch circuit portion or located in a remainder of said electrical  
8 distribution system.

1 12. The device according to claim 11, further comprising an interrupting mechanism  
2 responsive to a signal from said discriminator, wherein said interrupting mechanism  
3 does not disconnect said load from said electrical distribution system when said arc  
4 fault is located in said remainder of said electrical distribution system.

1 13. The device according to claim 11, wherein said first and second sensors detect  
2 fluctuations in load current or line voltage, respectively, as step changes, wherein  
3 those arc faults occurring in said protected branch circuit portion produce contrary  
4 step directions with respect to those arc faults occurring in said remainder of said  
5 electrical distribution system.

1 14. The device according to claim 13, wherein said first sensor is a di/dt sensor and  
2 said second sensor is a dv/dt sensor.

1 15. The device according to claim 14, wherein said di/dt sensor converts said current  
2 steps into di/dt pulses and said dv/dt sensor converts said voltage steps into dv/dt  
3 pulses, wherein a direction of said steps is identifiable from polarities of leading edges  
4 of said pulses.

1 16. The device according to claim 15, wherein an arrival of one of a di/dt pulse and a  
2 dv/dt pulse initiates a predetermined polling interval, within which interval an  
3 occurrence of an other of said di/dt pulse and said dv/dt pulse is used by said  
4 discriminator to establish a location of said arc fault within said electrical distribution  
5 system.

1 17. The device according to claim 16, wherein said predetermined polling interval is  
2 followed by a predetermined quiet period during which an absence of di/dt or dv/dt  
3 pulses is a prerequisite for initiating a next polling interval.

1 18. The device according to claim 15, further comprising a clamp for mitigating an  
2 erroneous signal following said leading edges of said di/dt or dv/dt pulses.

1 19. The device according to claim 18, wherein said erroneous signal is an oscillatory  
2 ringing from one of said first and second sensors.

1 20. The device according to claim 15, further comprising a gate, wherein an absence  
2 of said dv/dt pulses prevents said gate from delivering said di/dt pulses to said  
3 discriminator.

1 21. The device according to claim 15, wherein said di/dt or dv/dt pulses are  
2 exclusively arc cessation pulses.

1 22. The device according to claim 21, further comprising at least one of a zero cross  
2 current detector and zero cross voltage detector for characterizing one of line current  
3 and line voltage respectively, wherein said discriminator determines a plurality of  
4 phase angles of said di/dt or dv/dt pulses with respect to a zero crossing signal, and  
5 wherein arc cessation pulses are those pulses that occur within a predetermined range  
6 of said plurality of phase angles.

1 23. The device according to claim 22, wherein arc cessation pulses are those pulses  
2 that occur during each half cycle subsequent to a peak current or voltage.

1 24. The device according to claim 11, wherein said discriminator is a microprocessor.

1 25. The device according to claim 24, further comprising first and second hold  
2 circuits, wherein said current fluctuation signal and voltage fluctuation signal are held  
3 for pre-determined times in said first and second hold circuits, respectively, to allot  
4 said microprocessor sufficient time to recognize said fluctuations.

1 26. The device according to claim 11, wherein said load is an inductive load, and said  
2 device further comprises:

3 a line voltage zero cross detector; and  
4 a load current zero cross detector;  
5 wherein said zero cross detectors determine a phased relationship between line  
6 voltage and load current, and wherein said discriminator uses voltage fluctuations,  
7 current fluctuations, and said phased relationship to determine whether an arc fault or  
8 arc mimicking noise is located in said branch circuit portion or located in said  
9 remainder of said electrical distribution system.

1 27. The device according to claim 26, further comprising an interrupting mechanism  
2 responsive to a signal from said discriminator, wherein said interrupting mechanism  
3 does not disconnect said load from said electrical distribution system when said arc  
4 fault is located in said remainder of said electrical distribution system.

1 28. The device according to claim 11, further comprising at least one of a line voltage  
2 analog to digital converter connected to said line voltage sensor and a load current  
3 analog to digital converter (ADC) connected to said load current sensor;

4 wherein said discriminator receives signal from at least one of said analog to  
5 digital converters;

6 wherein said fluctuations in said load current or said line voltage, respectively,  
7 are determined using area comparison of half cycles of the power line frequency, and

8            wherein those arc faults occurring in said protected branch circuit portion  
9            produce contrary changes in current and voltage areas with respect to those arc faults  
10           occurring in said remainder of said electrical distribution system.

1           29. The device according to claim 28, wherein said load is an inductive load and said  
2           device further comprises:

3                  a voltage zero cross detector; and

4                  a current zero cross detector;

5                  wherein said half cycle periods are identified by said zero cross detectors, said  
6           voltage and current half cycle periods being in phased relationship dependent on said  
7           load.

1           30. The device according to claim 28, further comprising an interrupting mechanism  
2           responsive to a signal from said discriminator, wherein said interrupting mechanism  
3           does not disconnect said load from said electrical distribution system when said arc  
4           fault is located in said remainder of said electrical distribution system.

1           31. The device according to claim 11, wherein said fluctuations in load current are  
2           sensed across an impedance inserted in series with the line.

1           32. The device according to claim 31, wherein said impedance is a resistance.

1           33. The device according to claim 11, where said fluctuations in line voltage are  
2           sensed from an output of a high pass filter.

1           34. The device according to claim 11, further comprising means for introducing  
2           impedance in series with said power line, wherein a fluctuation in load current  
3           produces an enhanced fluctuation in line voltage.

1           35. The device according to claim 34, wherein said introduced impedance is located  
2           in a separate housing apart from said device.

1 36. The device according to claim 11, wherein said device is responsive to voltage  
2 and current fluctuations occurring during either polarity of the power line frequency.

1 37. The device according to claim 11, further comprising a gate, wherein absence of a  
2 voltage fluctuation signal opens said gate to prevent delivery of a current fluctuation  
3 signal to said discriminator.

1 38. The device according to claim 11, wherein said current fluctuations and voltage  
2 fluctuations are exclusively associated with arc extinguishing.

1 39. The device according to claim 38, further comprising at least one of a zero cross  
2 current detector and a zero cross voltage detector for characterizing line current and  
3 line voltage respectively;

4 wherein said discriminator determines a plurality of phase angles of voltage  
5 fluctuation and current fluctuation events with respect to a zero crossing signal; and

6 wherein arc cessation fluctuations are those that occur within a predetermined  
7 range of said plurality of phase angles.

1 40. The device according to claim 39, wherein arc cessation fluctuations are those  
2 that occur during each half cycle subsequent to a peak current or voltage.

Sub 3 41. An arc fault protection device, protective of a branch circuit portion of an  
2 electrical distribution system and connected to a load, comprising:  
3 means for detecting fluctuations in load current;  
4 means for detecting fluctuations in line voltage; and  
5 means for comparing the polarities of said fluctuations;  
6 wherein said comparison is indicative of whether an arc fault signature  
7 indicative of a potential arc fault is located in said branch circuit portion or located in  
8 a remainder of said electrical distribution system.

1 42. A method for protecting a branch circuit portion of an electrical distribution  
2 system from an arc fault, said branch circuit portion being connected to a load,  
3 comprising the steps of:

4 detecting fluctuations in load current;

5 detecting fluctuations in line voltage; and

6 comparing the polarities of said fluctuations;

7 wherein the step of comparing indicates whether an arc fault or arc mimicking  
8 noise is located in said branch circuit portion or located in a remainder of said  
9 electrical distribution system.

1 43. An arc fault protection device, protective of a branch circuit portion of an  
2 electrical distribution system and connected to a load, comprising:

3 a high frequency portion which looks at instantaneous changes on a voltage  
4 wave and a current wave of said system, wherein a relationship between said  
5 instantaneous changes indicates whether a transient is upstream or downstream; and

6 a low frequency portion which looks for a change in a fundamental frequency  
7 of said system and for changes in a plurality of harmonics of said fundamental  
8 frequency, wherein a sudden increase in said voltage wave accompanied by a sudden  
9 increase in said current wave indicates that said transient is upstream, and wherein a  
10 sudden increase in said voltage wave not accompanied by a sudden increase in said  
11 current wave indicates that said transient is downstream.

1 44. The device according to claim 43, wherein said plurality of harmonics includes a  
2 range from said fundamental frequency through its 10<sup>th</sup> harmonic.

1 45. A method for protecting a branch circuit portion of an electrical distribution  
2 system from an arc fault, said branch circuit portion being connected to a load,  
3 comprising the steps of:

4 high frequency filtering a voltage wave and a current wave of said system;

5 determining whether a relationship exists between instantaneous changes on  
6 said high frequency filtered voltage wave and said high frequency filtered current

7 wave of said system, and if so, whether said relationship indicates whether a transient  
8 is upstream or downstream;

9 low frequency filtering said voltage wave and said current wave of said  
10 system; and

11 determining whether a change in a fundamental frequency of said system and  
12 a change in a plurality of harmonics of said fundamental frequency occur, wherein a  
13 sudden increase in said low frequency filtered voltage wave accompanied by a sudden  
14 increase in said low frequency filtered current wave indicates that said transient is  
15 upstream, and wherein a sudden increase in said low frequency filtered voltage wave  
16 not accompanied by a sudden increase in said low frequency filtered current wave  
17 indicates that said transient is downstream.

1 46. An arc fault detector for a power line system, comprising:

2 an upstream/downstream discriminator circuit;

3 wherein during intervals when a line voltage and a line current are of a same  
4 polarity, said discriminator circuit detects when steps in load current and steps in line  
5 voltage are in phase for upstream caused transient events, and out of phase for  
6 downstream caused transient events; and

7 wherein during intervals when said line voltage and said line current are of  
8 opposite polarity, said discriminator circuit detects when steps in load current and  
9 steps in line voltage are out of phase for upstream caused transient events, and in  
10 phase for downstream caused transient events.

1 47. An arc fault detector as in claim 46, wherein said transient events produce a high  
2 frequency spectrum.

1 48. An arc fault detector as in claim 46, wherein said transient events produce a low  
2 frequency spectrum.

1 49. An arc fault detector as in claim 46 wherein said steps in load current are detected  
2 with a current transformer.



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1 50. An arc fault detector as in claim 46 wherein said steps in load current are detected  
2 across an impedance connected in series with said power line.

1 51. An arc fault detector as in claim 46, wherein said steps in line voltage are  
2 detected with a high pass filter connected across said power line.

1 52. An arc fault detector as in claim 46, wherein said steps in load current produced  
2 by steps in line voltage are connected to at least one input of a microprocessor.

1 53. An arc fault detector as in claim 46, wherein said out of phase steps in line  
2 voltage and load current are produced by a line voltage drop across an upstream line  
3 impedance.

1 54. An arc fault detector as in claim 53, wherein said line impedance is the inherent  
2 line impedance of said power line.

1 55. An arc fault detector as in claim 53, wherein said line impedance is an impedance  
2 introduced within said power line.